CHAPTER

2

Overview of Water Resources

2.1 INTRODUCTION

This chapter provides an overview of the physical, climatic, and demographic characteristics that shape water use in the Phoenix Active Management Area (AMA), as well as a description of the four main water supplies available to the AMA:

- groundwater
- surface water, primarily from the Salt, the Verde, the Agua Fria, and the Gila Rivers
- Central Arizona Project (CAP) water
- effluent or treated wastewater

To achieve safe-yield in the Phoenix AMA by 2025, it is necessary to increase the use of renewable water supplies and decrease groundwater withdrawals in conjunction with efficient water use. Each of these water sources has characteristics that limit the volumetric and geographic availability of the usable supply. The amount of groundwater present within water-holding alluvial deposits underground is vast. However, most groundwater is too deep to be pumped efficiently. In addition, manmade and natural causes have rendered much groundwater of insufficient quality for many uses without costly treatment. Historically, the greatest pumping of groundwater has occurred in many areas where groundwater of sufficient quality is readily accessible to groundwater right holders. This has often led to drops in groundwater levels and occasionally, land subsidence and earth fissures in those areas. Artificial recharge of the aquifers may mitigate depletion, but excessive pumping can cause permanent compaction of the aquifer and its water storing capacity.

Flows of surface water from the Salt, the Verde, the Agua Fria, and the Gila Rivers have long been stored in reservoirs for users downstream. Only portions of the AMA have users with land who have appropriated rights to surface water. Large areas, including many municipal, agricultural, and industrial users, are ineligible to receive surface water. Despite the control over supply afforded by the regulatory storage reservoirs, surface water availability is variable from year to year. Annual surface water flows vary greatly with weather patterns. In years of drought, insufficient surface water is often augmented by pumping additional groundwater. Since 1985, CAP water has been delivered by aqueduct from the Colorado River. Although use has increased rapidly, high costs and lack of infrastructure have hindered direct use. Effluent or treated wastewater is an underutilized supply in the AMA. Generally, effluent is used for non-potable uses such as landscape watering. Effluent has the potential to replace potable supply when potable water is not necessary for the use. Currently, however, the AMA's largest treatment facility is located downstream from most users and a portion of the effluent produced at the facility flows out of the AMA.

2.2 OVERVIEW OF ACTIVE MANAGEMENT AREA CHARACTERISTICS

The Phoenix AMA is located in central Arizona and is one of the five AMAs mandated by the Groundwater Code (Code). The Pinal, Prescott, Santa Cruz, and Tucson AMAs are the others. The Phoenix AMA covers 5,646 square miles and consists of seven groundwater subbasins (Figure 2-1). They are the East Salt River Valley (East SRV) Subbasin, the West Salt River Valley (West SRV) Subbasin, the Rainbow Valley Subbasin, the Hassayampa Subbasin, Lake Pleasant Subbasin, Carefree Subbasin, and the Fountain Hills Subbasin. The AMA is in the basin and range physiographic province, which is characterized by broad, gently sloping alluvial plains separated by predominately north to northwest trending mountains. Elevations range from less than 800 feet above mean sea level (msl) at Gillespie Dam to over 6,000 feet above msl in the Superstition Mountains in the eastern portion of the AMA.

The Phoenix AMA is drained by the Gila River and four principal tributaries: the Salt, the Verde, the Agua Fria, and the Hassayampa Rivers. Other tributaries include Queen Creek, New River, Skunk Creek, Cave Creek, Waterman Wash, and Centennial Wash. Regulatory water storage reservoirs have been

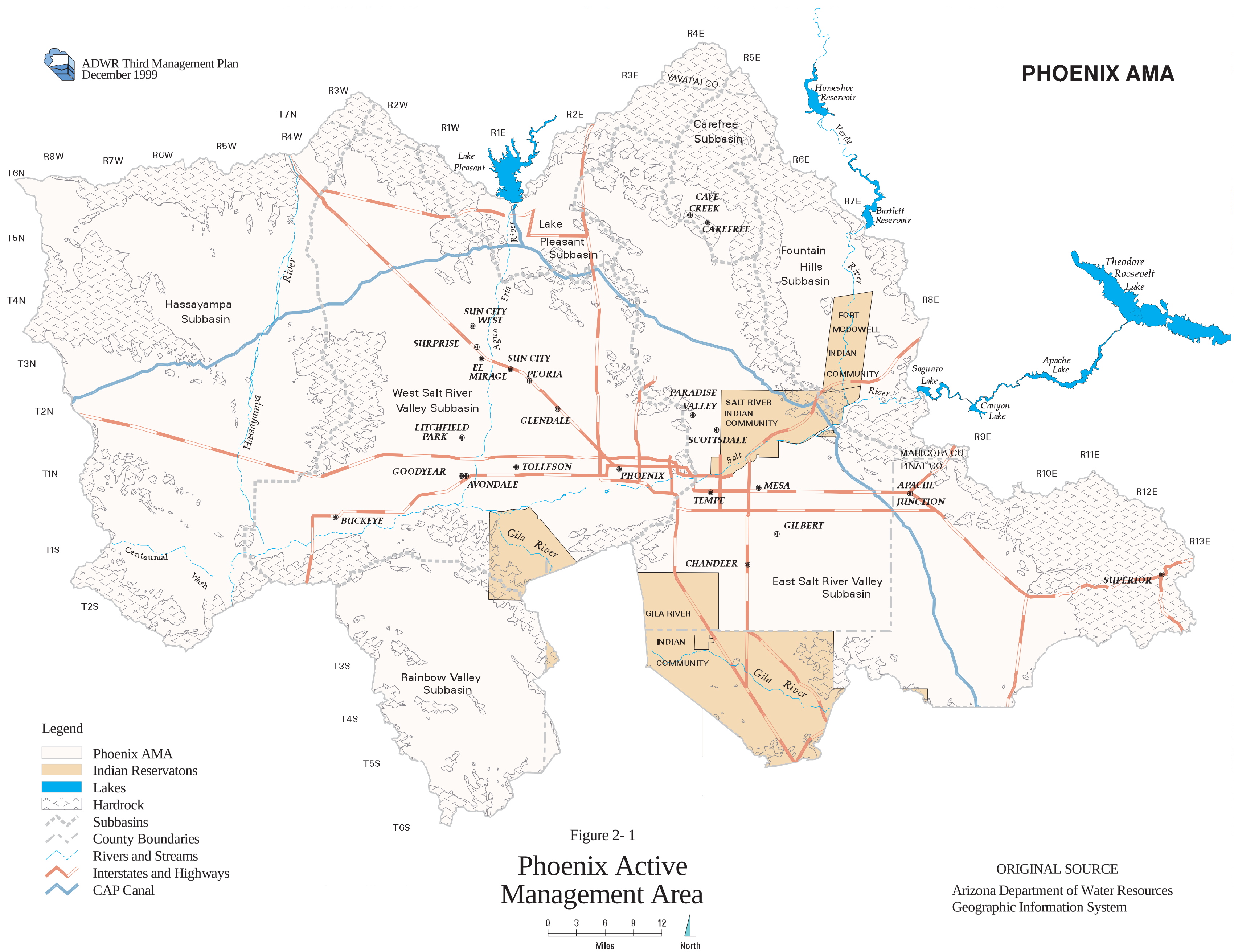


Figure 2- 1

Phoenix Active Management Area

ORIGINAL SOURCE
Arizona Department of Water Resources
Geographic Information System

constructed on the Salt, Verde, and Gila Rivers and for the Agua Fria River, allowing for a relatively high proportion of surface water use in some areas of the Phoenix AMA. Figure 2-1 shows the major rivers and washes in the AMA. All of the streams and washes within the AMA are ephemeral either naturally or due to upstream diversion. The Gila and Salt Rivers have sustained flow in their lower reaches due to return flows from nearby agricultural areas and discharges from wastewater treatment facilities.

Water may be transported within the AMA by canals and pipelines from points of diversion or from withdrawal to principal users. Groundwater withdrawn from adjacent wells; surface water diverted from the Gila, Salt, Verde, and Agua Fria Rivers; water from the CAP aqueduct; and, in some cases, effluent are all transported by canals and pipelines. Major canals include the Arizona Canal, Grand Canal, Beardsley Canal, Buckeye Canal, Arlington South Extension, Western Canal, Highline Canal, South Canal, Consolidated Canal, Eastern Canal, and the Roosevelt Water Conservation District Canal. The CAP aqueduct, transporting water from the Colorado River, cuts across the AMA from west to east. Pipeline distribution systems that connect with the canals and the CAP aqueduct have been developed by the larger municipalities and private water companies of the Phoenix metropolitan area. In certain instances, the water distribution systems interconnect with each other. Separate, dedicated pipelines to transport untreated CAP water or effluent have also been developed by several water providers in the AMA.

2.2.1 Climate

Located primarily in subtropical desert, the climate of the AMA is semi-arid. Long-term average temperature and precipitation are relatively uniform throughout the AMA due to the low topographic relief. Differences in elevation account for most variations.

The AMA has hot summers and mild winters. During July, the hottest month, daytime high temperatures are generally between 100° F and 110° F, with nighttime lows usually between 75° F and 85° F. January, the coolest month, generally has daytime high temperatures between 60° F and 70° F. Nighttime lows are usually between 35° F and 45° F.

Annual precipitation is limited, averaging seven to eight inches across the AMA, although higher elevations receive more rainfall. There are two distinct precipitation periods during the year, both of which are erratic and variable from year to year. In July and August, tropical air from the Gulf of Mexico is carried to the AMA by upper level winds from the southeast, frequently resulting in thunderstorms. Heavier late summer rains sometimes result from tropical storms moving north along the Sierra Madre of Mexico. During the winter months, precipitation comes from storms originating in the northern Pacific carried southward and eastward by the jet stream across the continent. Winter precipitation is generally less intense but is more widespread and of longer duration than summer precipitation. Spring runoff from melting winter snow along the Mogollon Rim and in the White Mountains north and northeast of the AMA provides most of the surface water collected by the major regulatory storage reservoirs for use in the AMA.

Since records have been kept by the National Weather Service weather station in Phoenix, annual precipitation has ranged from less than 3 inches to nearly 20 inches. Prolonged periods of relatively wet or dry weather are common. Extensive droughts have occurred in the early 1900s, 1930s, and 1950s. Many shorter drought periods have occurred since records have been kept from the 1890s. During years of winter drought, less snowpack in the Salt, the Gila, and the Verde River watersheds results in less runoff into regulatory water storage systems on these rivers. This reduces surface water availability in the AMA during those periods, resulting in higher groundwater pumping to make up for the surface water shortage.

Average annual evapotranspiration (vegetative water loss from plant transpiration and soil evaporation) is approximately 79 inches per year (Arizona Meteorological Network, 1998). Despite late summer rains, summer is the period of greatest evaporation potential and peak water demand for irrigation of landscapes, crops, and golf courses.

2.2.2 Demographic, Economic, and Land Use Characteristics

The Phoenix AMA includes large portions of Maricopa County and smaller sections of Pinal and Yavapai Counties. Most of the area is undeveloped, remaining in native desert habitat. Urban and agricultural development within the AMA is concentrated in the East SRV and West SRV Subbasins. Phoenix, the state's largest city, and its surrounding metropolitan area, the largest and most populous urban area in Arizona, are centrally located in the AMA. The densely populated urban area extends several miles east and west of Phoenix and includes the cities of Mesa, Glendale, Scottsdale, Tempe, Chandler, Peoria, Gilbert, Goodyear, and many smaller communities. Outside the East SRV and West SRV Subbasins, most of the remaining population in the AMA inhabit outlying areas of metropolitan Phoenix, which extends into the Fountain Hills Subbasin (Town of Fountain Hills) and the Carefree Subbasin (the communities of Carefree and Cave Creek). Urban population growth in the AMA has been rapid since World War II. During the 1990 to 1995 period, the population of the AMA grew from 2,133,915 to 2,549,931 and is expected to grow to 4,482,876 by the year 2025.

Extensive agricultural development is located primarily in the central and southern East SRV Subbasin and the central and southern portions of the West SRV Subbasin. Localized areas of agricultural development are located in the southern portion of the Hassayampa Subbasin and the northern portion of the Rainbow Valley Subbasin. All crops grown in the AMA require irrigation.

In addition to agriculture, other industries that make up the Phoenix AMA's economy include tourism and recreation, power generation, manufacturing, government, health, and research. Each of these industries, along with the area's municipalities and agriculture, depends upon groundwater resources to varying degrees.

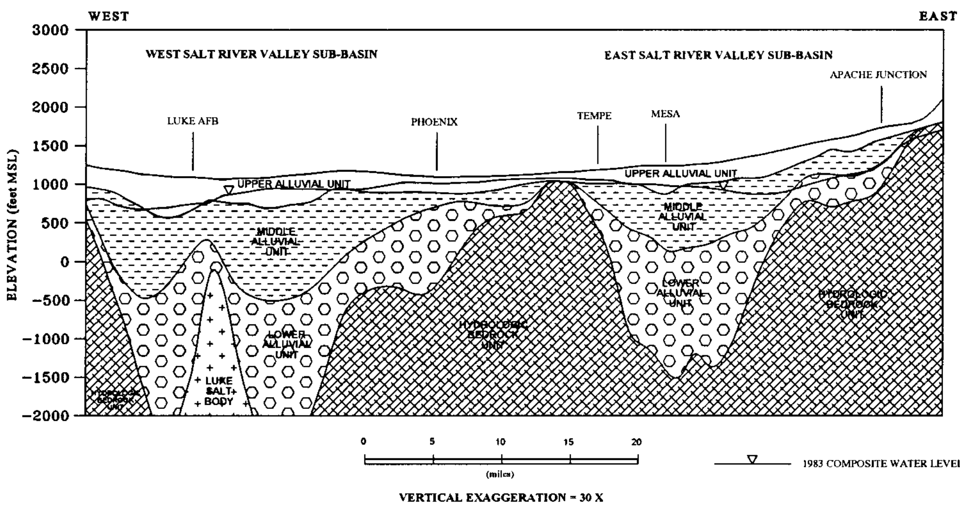
2.3 GROUNDWATER

There are seven groundwater subbasins in the AMA: the East Salt River Valley Subbasin, the West Salt River Valley Subbasin, the Hassayampa Subbasin, the Rainbow Valley Subbasin, the Fountain Hills Subbasin, the Lake Pleasant Subbasin, and the Carefree Subbasin. Each subbasin has its own unique hydrogeologic characteristics, and a number of factors influence groundwater conditions in each. These include groundwater inflow and outflow, depth to groundwater, withdrawals and recharge, surface water conditions, subsidence potential, and quality of groundwater in different locations. The use of renewable water supplies is one of the most important factors in counteracting groundwater declines in the AMA.

The primary sources of groundwater in the Phoenix AMA are basin-fill sediments. While the basin-fill sediments that underlie much of the AMA are extremely heterogenous, three distinct water bearing units are identified for most of the subbasins of the AMA: an upper alluvial unit, a middle fine-grained unit, and a lower conglomerate unit. These units are illustrated in Figure 2-2, which shows a hydrogeologic cross-section with exaggerated vertical scale running west to east across the East SRV and West SRV Subbasins. Although conditions and circumstances vary across the AMA, most groundwater is pumped from the middle alluvial unit. At ideal locations, large capacity wells in the basin-fill sediments can yield up to a few thousand gallons of water per minute. Bedrock, consisting of various metamorphic and igneous rock, underlies the basin-fill sediments. The bedrock has little groundwater storage or production capacity and is not considered to be an aquifer.

Groundwater conditions change over time due to natural and human-induced fluctuations in the amount of water being added or removed. Because groundwater flows very slowly underground, the effects of pumping and recharge can alter the shape of the water table for long periods of time. Water that is naturally or artificially recharged can mound up underground, while pumping can create a cone of

FIGURE 2-2
SCHEMATIC DIAGRAM OF THE SALT RIVER VALLEY SUBBASINS
PHOENIX ACTIVE MANAGEMENT AREA



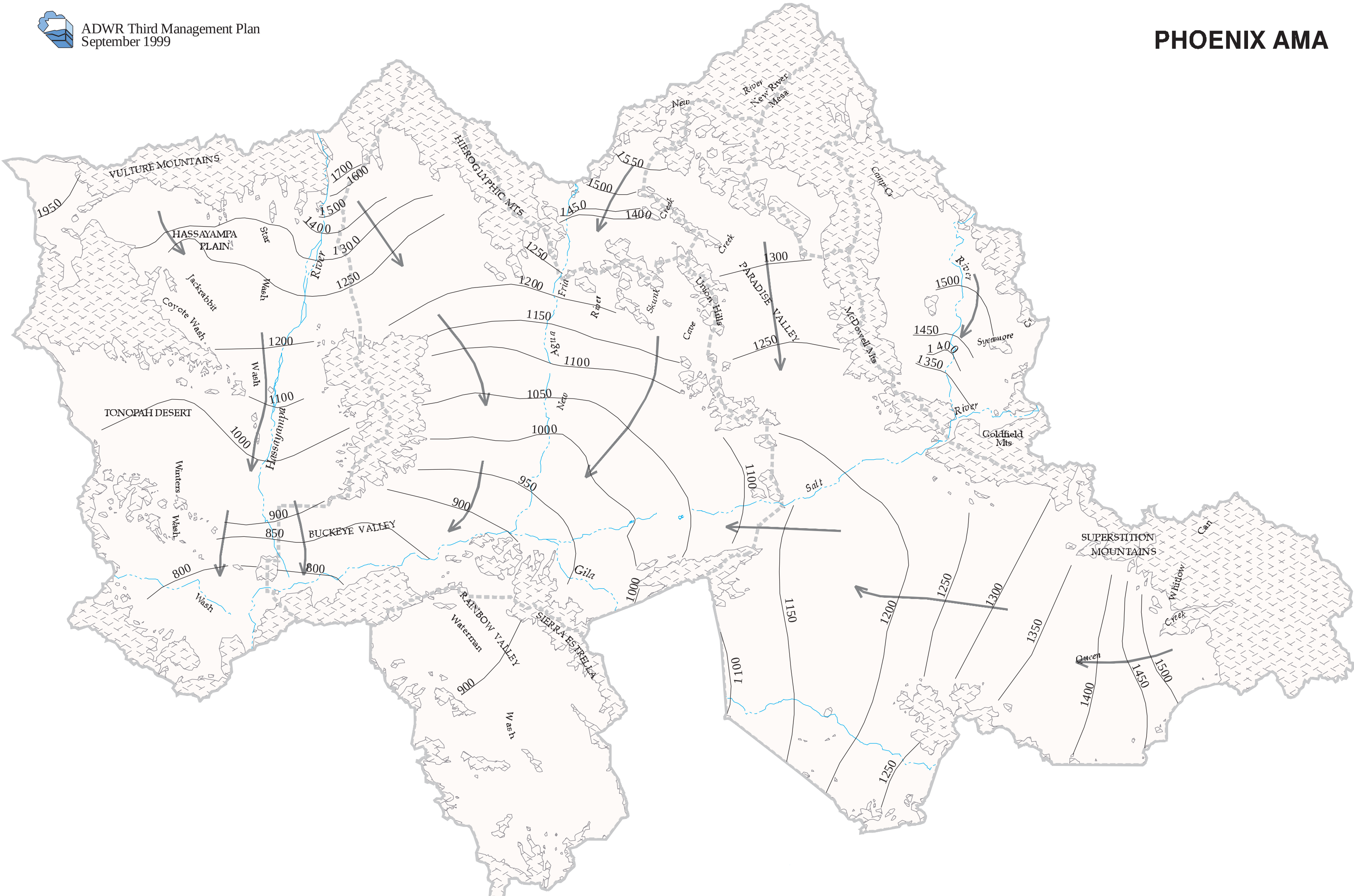
depression in the water table. Major changes in water level elevations occurred after the development of more effective well technology in the 1940s. The new well pumps allowed a much greater volume of groundwater to be pumped than had been possible earlier. These conditions are occurring in the Phoenix AMA and are described according to each subbasin in the following sections. Figures 2-3 through 2-6 are among several types of maps used to illustrate groundwater conditions in the Phoenix AMA. These are based on the location of the water table–the "surface" of the layer of groundwater–relative to either land surface, sea level, or the water table at a different point in time. When this information is known for a number of wells in an area, contour lines can be drawn around areas with similar conditions. Depth-to-water maps indicate the distance from the surface of the land to the top of the water table at different locations in the AMA. Water level elevation maps are used to show the level of the water table relative to a fixed reference point: mean sea level. The slope of the water table and the direction of groundwater flow can be determined using a water level elevation map. Water level change maps show areas where the water table has fallen or risen during a given time period.

Figure 2-3 shows 1900 water level elevations above msl, changes in water level elevations from 1900 to 1998 are shown on Figure 2-4, and 1998 water level elevations and depth to water below land surface are shown on Figures 2-5 and 2-6, respectively.

2.3.1 Data Sources

Data sources from within the Department and from outside sources are used to evaluate groundwater conditions. The Department's Land Subsidence and Aquifer Storage Unit is a newly established unit of the Hydrology Division. The unit has recently conducted a baseline Global Positioning Survey of land surface elevation in the Apache Junction area. In the future, the unit will establish land subsidence and aquifer storage monitoring networks in the Phoenix, Pinal, and Tucson AMAs.

PHOENIX AMA



Phoenix AMA Boundary
Water Elevation Isolines (Feet Above Mean Sea level)
Hardrock
River
Groundwater Subbasins
Direction of Groundwater Flow

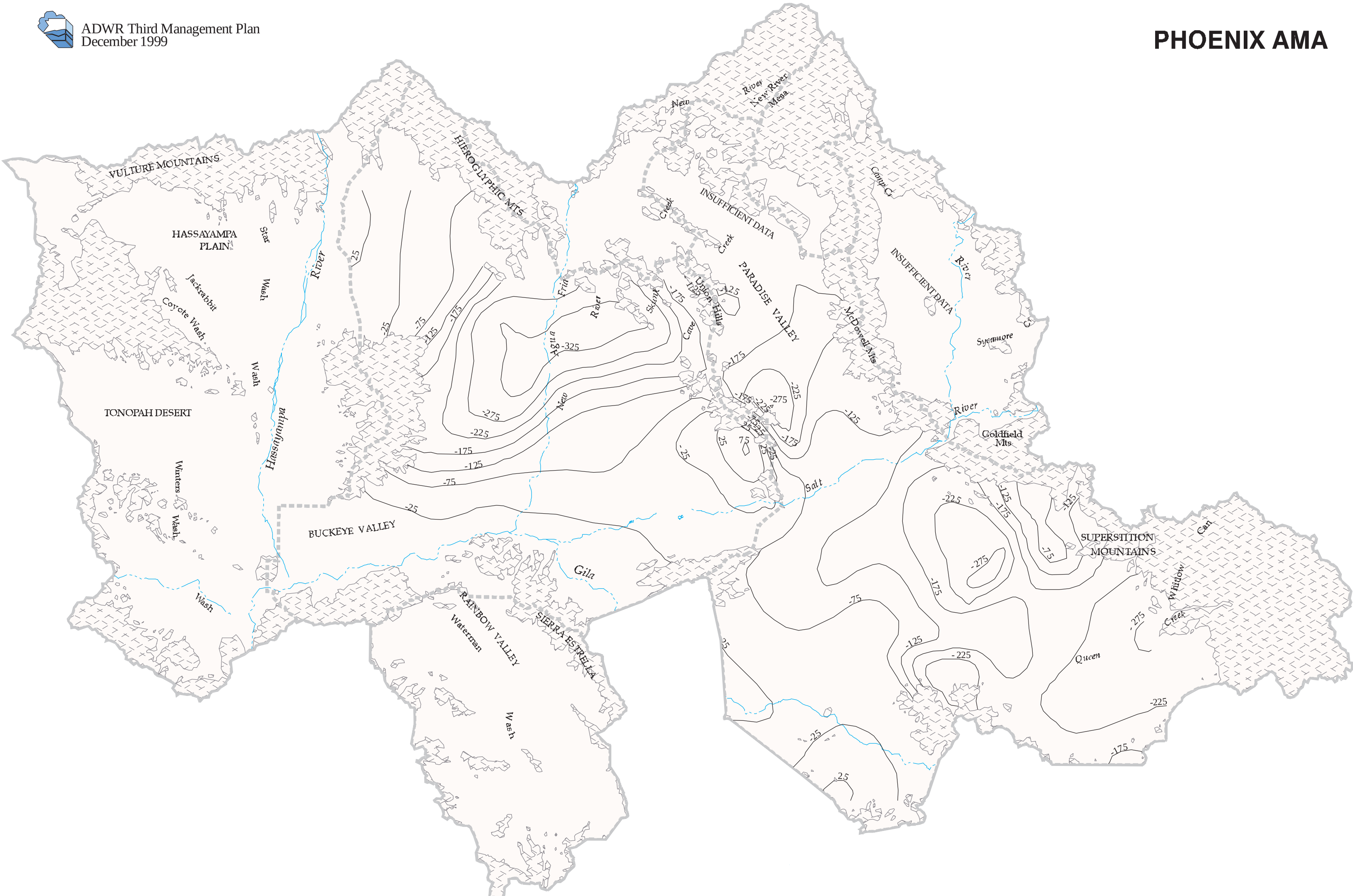
Figure 2 - 3

Water Elevations
1900

0 3 6 9 12
Miles
North

ORIGINAL SOURCE
Arizona Department of Water Resources
Hydrology Division

PHOENIX AMA



Phoenix AMA Boundary
Water Elevation Change Isolines (Feet)
- 20 Water Level Decline
20 Water Level Rise
Hardrock
River
Groundwater Subbasins

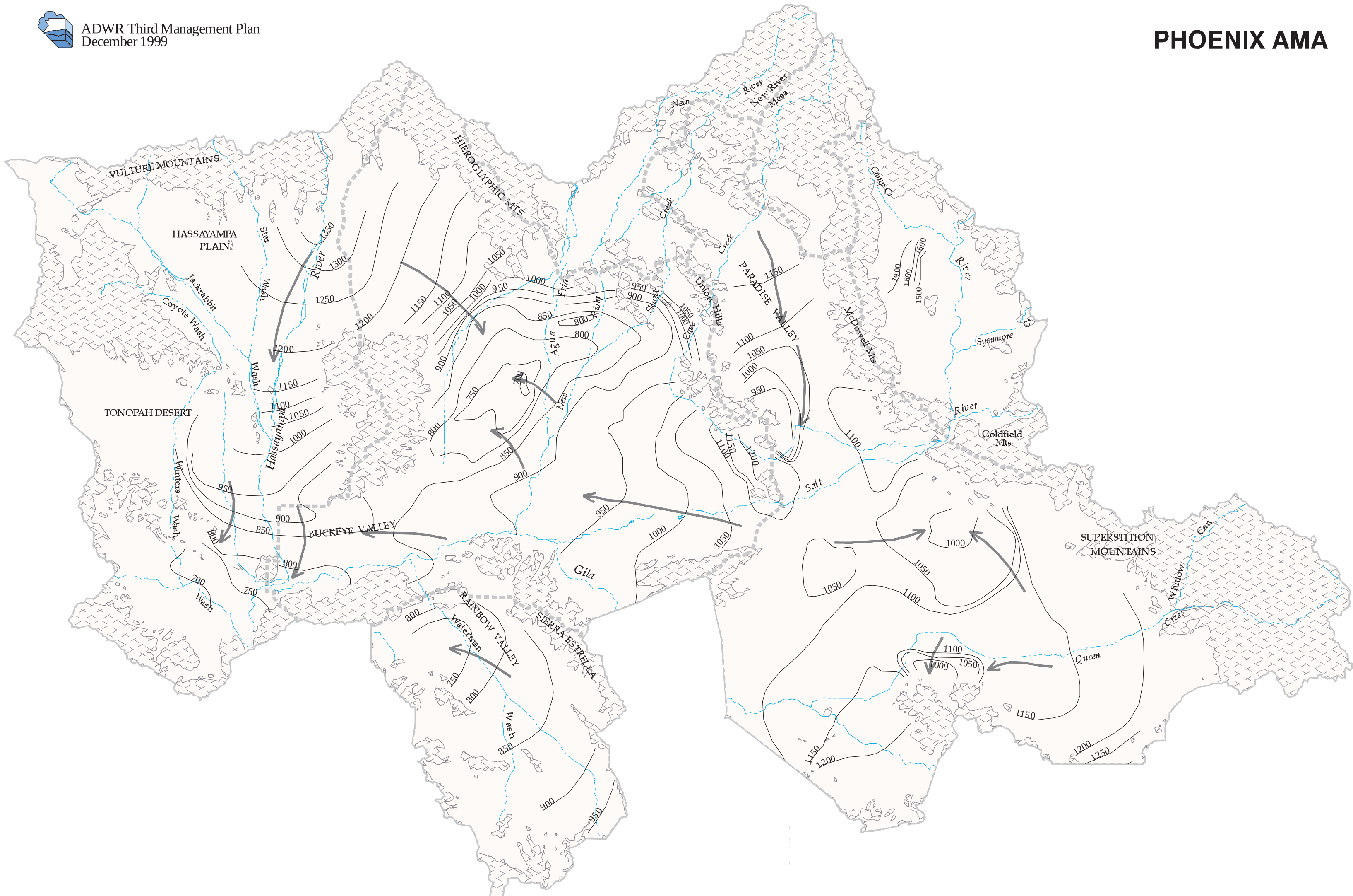
Figure 2- 4
Water Elevation Change
1900 - 1998 Lower Aquifer

0 3 6 9 12
Miles
North

ORIGINAL SOURCE
Arizona Department of Water Resources
Hydrology Division

ADWR Third Management Plan
December 1999

PHOENIX AMA



Phoenix AMA Boundary
Water Elevation Isolines (Feet Above Mean Sea Level)
Hardrock
River
ADWR Sub Basins
Direction of Ground Water Flow

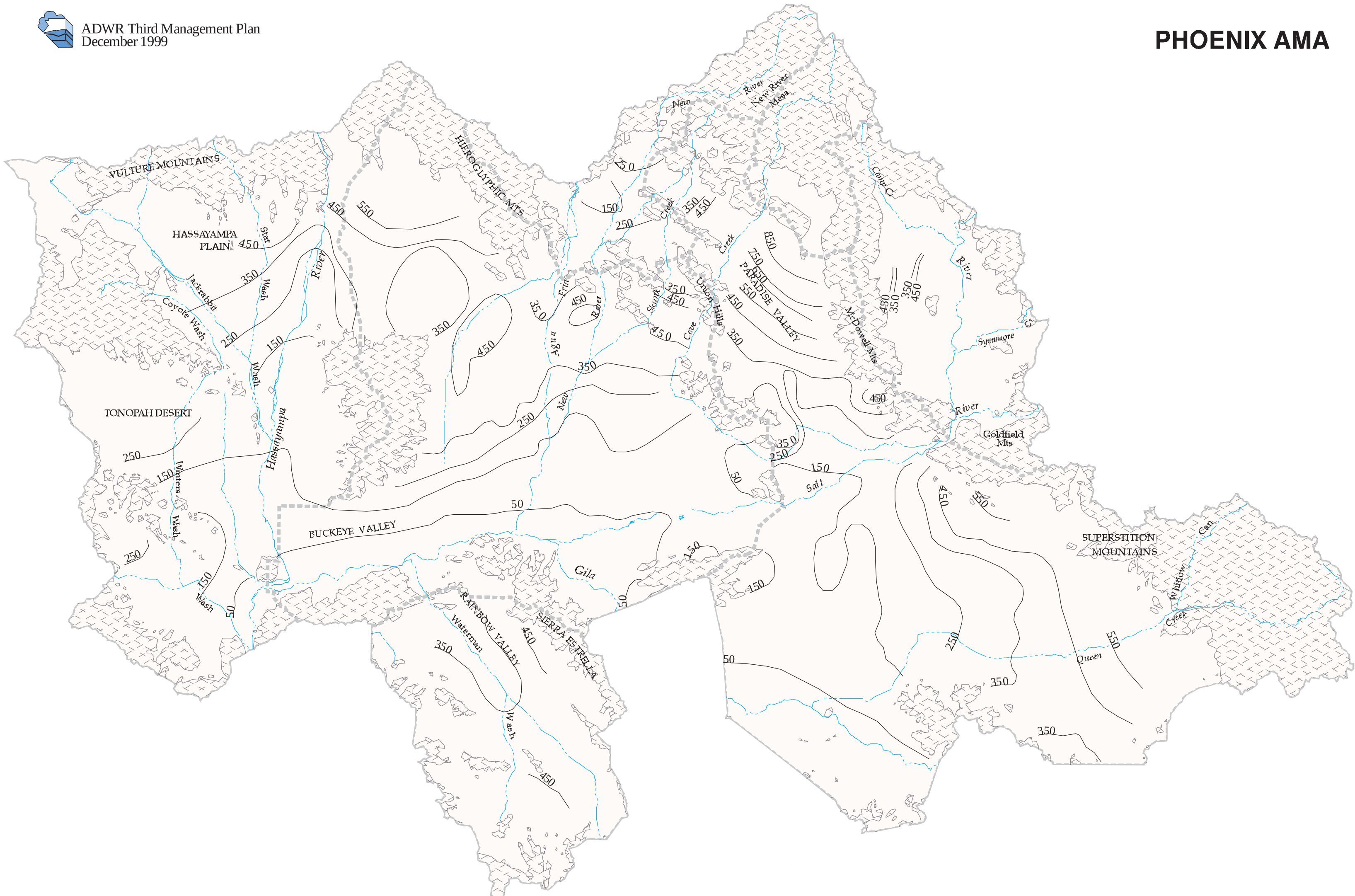
Figure 2 - 5

Water Elevations
1998

0 3 6 9 12
Miles
North

ORIGINAL SOURCE
Arizona Department of Water Resources
Hydrology Division

PHOENIX AMA



Phoenix AMA Boundary
Depth to Water, Feet Below Land Surface
Inferred Depth to Water, Feet Below Land Surface
Hardrock
River
ADWR Sub Basins

Figure 2 - 6
Depth to Water

0 3 6 9 12
Miles
North

ORIGINAL SOURCE
Arizona Department of Water Resources
Hydrology Division

The Basic Data Section of the Department conducts yearly water level measurements at designated index wells throughout the AMA. More in-depth analysis occurs every five years when a broader cross-section of wells is measured for water levels and tested for inorganic constituents. These data are periodically used to prepare hydrologic maps addressing water levels and water quality in the AMA subbasins. Phoenix AMA map series of 1991-1992 water levels for the entire AMA have been published.

A three-dimensional transient flow groundwater model of the Salt River Valley (2,240 square miles of the East SRV and West SRV Subbasins) has been developed by the Department to provide a tool to simulate future groundwater conditions. This is done by testing various water management strategies designed to optimize the use of renewable water resources and conserve groundwater resources. The model area includes the cities of Phoenix, Tempe, Scottsdale, Mesa, Chandler, Glendale, Peoria, Gilbert, Sun City, Goodyear, Buckeye, and Apache Junction as well as many smaller cities and Indian communities. The model simulates groundwater flow conditions using the United States Geological Survey model MODFLOW. The Salt River Valley model is a three-layered model that simulates groundwater flow in the regional aquifer system. Results from an early application of the model are in the Department's report "Analysis of Future Water Use and Supply Conditions: Current Trends Alternative 1989-2025." Planned future modifications to the model include land subsidence prediction capabilities and refined geologic structure data.

Other groundwater information is compiled by federal, state, and local entities in addition to the Department. Water quality sampling is conducted by ADEQ and results are available in compiled databases at the agency. The United States Geological Survey has published multiple reports on water resources, including recent reports on the East SRV and West SRV Subbasins (Laney and Hahn, 1986); (Brown and Pool, 1989).

2.3.2 <u>East Salt River Valley Subbasin</u>

The East SRV Subbasin is one of the larger subbasins in the AMA, covering approximately 1,710 square miles. Located in the eastern half of the AMA, it is a broad, gently sloping alluvial plain bounded on the north and east by the New River, McDowell, Usery, Goldfield, and Superstition Mountains; on the south by the Santan and Sacaton Mountains; and on the west by the South Mountains, the Papago Buttes, the Phoenix Mountains, Union Hills, and the Deem Hills.

The Salt River channel crosses the central portion of the basin from east to west. The ephemeral Indian Bend Wash, much of which is a channelized greenbelt in the City of Scottsdale, flows south and drains the central portion of the subbasin until its confluence with the Salt River. Queen Creek, also ephemeral, drains the eastern portion of the subbasin until its confluence with the Gila River, which crosses the far southern portion of the subbasin and flows from east to west. Cave Creek, also ephemeral, drains the northern portion of the subbasin southwestward into the West SRV Subbasin.

Three hydrogeologic units are recognized within the basin-fill sediments in the East SRV Subbasin: an upper sand and gravel unit, a middle silt and clay unit, and a lower conglomerate unit (Laney and Hahn, 1986). The upper unit mainly consists of sand and gravel with some interbedded silt and clay. The upper unit ranges in thickness from less than 100 feet near the basin margins to over 350 feet in some parts of the basin. The middle unit consists mainly of silt and clay with some interbedded sand and gravel. Near the basin margins, the unit is coarser and typically cannot be distinguished from the upper and lower units. The middle unit ranges in thickness from less than 100 feet near the basin margins to over 1,800 feet southeast of Gilbert. The lower unit consists mainly of conglomerate near the basin margins. The unit ranges in thickness from less than 100 feet near the basin margins to over 9,000 feet southeast of Gilbert.

Prior to extensive development, groundwater underflow entered the East SRV Subbasin from the north, south, and southeast. Groundwater flowed generally east to west within the subbasin toward and along the

Salt and Gila Rivers. Minor underflow exited the subbasin into the West SRV Subbasin between the Papago Buttes and South Mountain. Water levels had ranged from greater than 1,500 feet above msl near the east and north basin margins to 1,150 feet above msl near Tempe Butte and south of South Mountain (Figure 2-3).

Since 1940 when extensive groundwater pumping to meet growing agricultural and municipal water demand began, water levels have declined significantly. Three large cones of depression in the Scottsdale, Mesa, and Santan Mountain areas have been created by agricultural pumping (Figure 2-4). In addition, water levels in the Scottsdale area declined 300 feet from 1900 to 1998 due to municipal use. Water levels declined by more than 400 feet near the Santan Mountains and 350 feet east of Mesa (Laney, Ross, and Litten, 1978).

In 1998 water level elevations ranged from approximately 900 feet above msl in the Scottsdale cone of depression to 1,500 feet above msl in the northern part of the subbasin (Figure 2-5). Depth to groundwater in 1998 ranged from less than 100 feet below land surface near the Salt and Gila Rivers to over 850 feet below land surface north of Paradise Valley and 550 feet below land surface near the Superstition Mountains (Figure 2-6). Today, most groundwater flows toward the three large cones of depression.

Assured Water Supply Rules (AWS Rules) require developers and water providers to demonstrate the availability of water for new subdivisions consistent with the management goal of the Phoenix AMA. Applicants must demonstrate the use of renewable supplies, rather than groundwater, to meet most demand for development for 100 years (see Chapter 5). Only groundwater physically available to a depth of 1,000 feet may be used as a part of an assured water supply. In the Apache Junction area of the East SRV Subbasin, current and committed demand has already accounted for all groundwater up to a depth of 1,000 feet and, thus, all groundwater allowed under the AWS Rules.

Although significant quantities of surface water are available to users in this subbasin (see section 2.4), groundwater pumping is still extensive in the Paradise Valley and the Sun Lakes areas by municipal and industrial users and in the Queen Creek vicinity by agricultural users.

2.3.3 West Salt River Valley Subbasin

Like the East SRV Subbasin, the West SRV Subbasin is one of the larger subbasins in the AMA (1,330 square miles) and is a broad, gently sloping alluvial plain. It is bounded on the north by the Hieroglyphic Mountains and Hedgpeth Hills; on the east by Union Hills, Phoenix Mountains, and Papago Buttes; on the south by the South Mountains, the Estrella Mountains, and Buckeye Hills; and on the west by the White Tank Mountains (Figure 2-1).

The Salt River channel meets the Gila River in the southern portion of the subbasin. When flowing, much of the subbasin drains from north to south into the Gila River via Skunk Creek, New River, the Agua Fria River, and Cave Creek. Skunk Creek drains into New River just east of Sun City, which subsequently flows into the Agua Fria River just south of Glendale Municipal Airport. The Agua Fria River joins the Gila River west of its confluence with the Salt River. Cave Creek flows from the East SRV Subbasin until it reaches the Arizona Canal Diversion Channel, which drains into Skunk Creek.

The West SRV Subbasin is hydrologically similar to the East SRV Subbasin. It also has three hydrogeologic units recognized within the basin-fill sequence, consisting of similar fill deposits. The upper unit ranges in thickness from less than 100 feet near the basin margins to over 500 feet in the Luke Air Force Base area. The middle unit ranges in thickness from less than 100 feet near the basin margins to over 1,300 feet southwest of Glendale. The lower unit ranges in thickness from less than 100 feet near the basin margins to over 10,000 feet southwest of Glendale. A large salt body, known as the Luke salt body, lies in the West SRV southeast of the Luke Air Force Base and occurs at a depth of 880 feet to over 6,000 feet. Geohydrologic data indicate that the upper part of the salt body has a local effect on groundwater salinity.

Historically, groundwater entered the West SRV Subbasin as underflow from the north, northwest, and southeast between the Sierra Estrellas and South Mountain. In addition, minor groundwater underflow entered the subbasin from the East SRV Subbasin between the Papago Buttes and South Mountain. Within the subbasin, groundwater flowed toward and along the Salt and Gila Rivers and finally exited the subbasin into the southern part of the Hassayampa Subbasin. Historic groundwater levels in the West SRV Subbasin ranged from 800 feet above msl along the western reaches of the Gila River to nearly 1,300 feet above msl in the north (Figure 2-3). Shallow groundwater conditions occurred in the Buckeye area.

Groundwater pumping for agriculture in the West SRV Subbasin began in the late 1800s from shallow irrigation wells along the Salt and Gila Rivers (Lee, 1905). Increases in well pumping capacity, expanding agriculture, and later, urban development have caused increased groundwater pumping. Groundwater levels have declined significantly, with two large cones of depression created by groundwater pumping near Luke Air Force Base and in Deer Valley near the Hedgpeth Hills. From 1923 to 1977, water levels declined by more than 300 feet in these areas (Ross, 1978).

In 1998, water levels ranged from 700 feet above msl in the Luke area cone of depression to 1,350 feet above msl in the northern area of the subbasin (Figure 2-5). Depth to groundwater during 1998 ranged from less than 50 feet below land surface near the Salt and Gila Rivers to over 550 feet below land surface near the Union Hills (Figure 2-6). Along the Gila River west of Goodyear, depth to groundwater may range from as shallow as 4 feet to as much as 20 feet below land surface. In the Buckeye area, shallow groundwater conditions have caused waterlogging problems with detrimental effects on crops (Montgomery & Associates, 1988). In spite of extensive groundwater pumping in the area, waterlogging problems persist because of the high volume of treated effluent discharged into the Salt River by the City of Phoenix's 91st Avenue Wastewater Treatment Plant (WWTP) and because of high volumes of water applied for agricultural irrigation to manage elevated salt levels (see section 2.3.10). Although some groundwater still flows westward from the West SRV Subbasin into the southern part of the Hassayampa Subbasin, much of the groundwater flows toward the two large cones of depression.

The West SRV Subbasin currently contains many water users who do not have access to many renewable supplies and rely heavily on groundwater, including municipal water providers such as Litchfield Park, Citizens Utilities - Sun City, Citizens Utilities - Sun City West, Citizens Utilities - Agua Fria, the City of El Mirage and Luke Air Force Base; agricultural users served by the Roosevelt Irrigation District; and numerous golf courses in the Sun City and Sun City West area that have their own grandfathered rights to pump groundwater.

2.3.4 Hassayampa Subbasin

In the far western portion of the AMA, the Hassayampa Subbasin covers 1,200 square miles and is a gently sloping alluvial plain bounded on the north by the Vulture Mountains and the Wickenburg Mountains; on the east by the White Tank Mountains; on the south by the Buckeye Hills and the Gila Bend Mountains; and on the west by the Big Horn Mountains, the Belmont Mountains, and the Palo Verde Hills (Figure 2-1). The area is drained by the Hassayampa River, which enters the subbasin in the northeast and joins the Gila River east of Arlington. The Gila River, which flows perennially with effluent from the west Phoenix metropolitan area, crosses the southeastern tip of the subbasin. Tributaries to the Hassayampa and Gila Rivers include Jackrabbit Wash and Centennial Wash, respectively.

The sequence of basin-fill sediments in the lower Hassayampa Subbasin consists of three hydrogeologic units designated as the upper, middle, and lower alluvium (Fugro, Inc., 1980). The upper unit is 30 to 60 feet thick and consists of sand and gravel. The middle unit, 230 to 300 feet thick, consists of clay and silt.

The lower unit, from 100 to more than 1,000 feet thick, consists of unconsolidated sand and moderately to well consolidated alluvial fan deposits.

Historically, groundwater entered the Hassayampa Plain from the northeast, most of which flowed south into the lower Hassayampa area. Groundwater also enters the southeastern part of the lower Hassayampa area as underflow from the southern part of the West SRV Subbasin. Groundwater levels historically ranged from 800 feet above msl in the southern area of the subbasin to more than 1,300 feet above msl in the extreme northern reaches of the subbasin (Figure 2-3). In the lower Hassayampa area, extensive groundwater pumping for agricultural development began in the early 1950s. Approximately 24,000 acres of land were under cultivation by 1960 and 22,500 acres were under cultivation in 1982 (Stulik, 1974). As a result of groundwater pumping, water levels have declined significantly in the agricultural areas of the subbasin. From the mid-1950s through 1998, water levels declined by as much as 70 feet in the Tonopah Desert and 90 feet in the Centennial Wash area, resulting in the creation of two large cones of depression in those areas. Data from 1998 shows groundwater levels ranging from 700 feet above msl in the southern area of the subbasin to 1,350 feet above msl in the northern section (Figure 2-5). Depth to groundwater in the Hassayampa Subbasin in 1998 ranged from less than 20 feet below land surface near the Gila River in Arlington Valley to over 700 feet below land surface near the Vulture Mountains.

After passing a bedrock constriction between the Belmont Mountains and the White Tank Mountains, groundwater currently flows from the northeast to southwest toward two cones of depression in the Tonopah Desert and Centennial Wash areas. Groundwater entering the southeastern part of the lower Hassayampa area from the southern part of the West SRV Subbasin is largely captured by the cone of depression in the Centennial Wash area.

2.3.5 Rainbow Valley Subbasin

The Rainbow Valley Subbasin is a gently sloping alluvial plain of approximately 420 square miles bounded on the north by the Buckeye Hills and the northern part of the Sierra Estrella, on the east by the Sierra Estrellas and the Palo Verde Mountains, on the south by the Haley Hills and the Booth Hills and the southern part of the Maricopa Mountains, and on the west by the Maricopa Mountains (Figure 2-1) (White, 1963). The area is drained by Waterman Wash, which joins the Gila River near Buckeye.

The basin-fill sequence which comprises the regional aquifer of the Rainbow Valley Subbasin consists of poorly sorted gravel, sand, silt, and clay (White, 1963). Due to a lack of geologic data, the regional aquifer is not well-defined. Wells are concentrated in the northern part of the subbasin; there are very few wells in other parts of the subbasin. Depth to bedrock in the Rainbow Valley Subbasin ranges from a few feet near the basin margins to a maximum verified depth of over 1,200 feet in the north-central part of the basin (White, 1963). More recent data suggest that the depth may exceed 9,600 feet in the central part of the basin (Oppenheimer, 1980).

Historically, groundwater may have entered the Rainbow Valley Subbasin from the Pinal AMA between the Palo Verde Mountains and the Haley Hills (White, 1963). Groundwater from the southern part of the Rainbow Valley Subbasin generally flowed toward the northwest. Water levels in the Rainbow Valley Subbasin were approximately 900 feet above msl (Figure 2-3). Water levels began declining in the early 1950s with the commencement of intensive agricultural development in the northern part of the subbasin. By 1982, water levels had declined by as much as 200 feet in the north and by about 12 feet further south near Mobile. Pumping in the north has created an extensive cone of depression there. Water levels in the subbasin in 1998 ranged from 750 feet above msl in the northwestern area to 950 feet above msl in the southeast area (Figure 2-5). Depth to groundwater in the Rainbow Valley Subbasin in 1998 ranged from 120 feet below land surface near the Buckeye Hills to over 400 feet near the cone of depression and further south in the Mobile Valley.

Available information suggests that the regional aquifer in the Rainbow Valley Subbasin is not currently connected to adjacent subbasins. Groundwater no longer flows into the subbasin from the Pinal AMA because of groundwater pumping in that AMA. Similarly, groundwater that historically flowed from the Rainbow Valley Subbasin into the West SRV Subbasin prior to development no longer does so because of groundwater pumping for agricultural irrigation in the northern part of the subbasin. In that area, groundwater flows toward the cone of depression.

2.3.6 Fountain Hills Subbasin

In the northeastern part of the AMA, the Fountain Hills Subbasin, covering approximately 360 square miles, is an extensively dissected alluvial plain bounded on the north and east by the Mazatzal Mountains and Stewart Mountain, on the south by the Usery Mountains and Sawik Mountain, and on the west by the McDowell Mountains (Figure 2-1). The subbasin is drained by the lower part of the Verde River, a perennial river regulated by Bartlett Dam near the northeastern boundary of the subbasin. The Verde River flows south along the axis of the basin, joining a regulated reach of the Salt River between Stewart Mountain Dam and Granite Reef Dam in the southern part of the subbasin. Tributaries to the Verde River include Camp Creek and Sycamore Creek.

Depth to bedrock in the Fountain Hills Subbasin ranges from a few feet near the basin margins to over 1,200 feet near the center of the basin (Ross, 1978); more recent data indicates the depth may exceed 4,800 feet (Oppenheimer, 1980). The regional aquifer consists of two distinct hydrogeologic units: an older basin-fill sequence and unconsolidated alluvium deposited by the Verde River. The unconsolidated alluvium underlies the modern floodplain of the Verde River.

The general direction of groundwater flow is from north to south, parallel to the axis of the subbasin and has likely remained unchanged since development has occurred in this subbasin. Available information suggests that the regional aquifer in the Fountain Hills Subbasin is not connected to adjacent subbasins. To date, groundwater pumping in the Fountain Hills Subbasin has been relatively minimal. In the 1920s, the City of Phoenix began diverting groundwater from the Verde River alluvium for municipal water supply. Currently, groundwater is pumped by Chaparral City Water Company, Fountain Hills Golf Course, the development of Rio Verde, and a number of domestic wells. Almost all groundwater pumping occurs in the southern part of the subbasin.

Long-term water level records are not available for the area; however, available information suggests that water levels have not been significantly affected by groundwater pumping in the subbasin. Depth to groundwater in 1998 ranged from 19 feet below land surface in the Verde River floodplain south of Bartlett Dam to over 500 feet below land surface near the McDowell Mountains.

2.3.7 Lake Pleasant Subbasin

In the northern part of the AMA, the Lake Pleasant Subbasin is a relatively small, gently sloping alluvial plain of 240 square miles bounded on the north by an unnamed ridge southeast of the Agua Fria River; on the east by the New River Mountains and an unnamed group of hills to the south; on the south by the Union, Deem and Hedgpeth hills; and on the west by the Hieroglyphic Mountains (Figure 2-1). The subbasin is drained by the lower part of the Agua Fria River, an ephemeral stream regulated by New Waddell Dam at the northern boundary of the subbasin; by New River, which heads in the New River Mountains to the northeast; and by Skunk Creek.

The basin-fill sediments comprising the regional aquifer of the Lake Pleasant Subbasin consist of unconsolidated to semi-consolidated silt, sand, and gravel, and locally may include interbedded basalt (Litten, 1979). Depth to bedrock in the Lake Pleasant Subbasin ranges from a few feet near the basin margins to over 800 feet near the center of the basin.

The general direction of groundwater flow, from north to south, has likely remained unchanged since little development has occurred in this subbasin. Groundwater flow directions suggest that the Lake Pleasant Subbasin is hydraulically connected with the West SRV and East SRV Subbasins. Groundwater enters the subbasin from the northeast and flows south along New River and into the West SRV Subbasin, both at the Agua Fria River east of the Hieroglyphic Mountains and at Skunk Creek between the Deem Hills and the Union Hills. Groundwater flows into the East SRV south of the town of New River and north of the Union Hills.

To date, the quantity of groundwater pumping in the Lake Pleasant Subbasin has been relatively minimal. Currently, groundwater is pumped by numerous domestic wells mainly near the town of New River, a few small, private water companies, and an outlet mall. Water levels for 1998 ranged from 1,550 feet above msl in the northern area of the subbasin to 1,300 feet above msl in the southern portion of the subbasin.

Long-term water level records are not available for the area; however, available information suggests that water levels have been significantly affected by groundwater pumping. Near the Town of New River, areas underlain by volcanic rock have experienced severe declines and many domestic wells have gone dry. Depth to groundwater in 1998 ranged from 11 feet below land surface in a local aquifer near the Town of New River to nearly 300 feet below land surface in the regional aquifer south of New River (Figure 2-6).

2.3.8 Carefree Subbasin

The Carefree Subbasin covers approximately 140 square miles. It is bordered on the east by the northernmost McDowell Mountains, on the north by a mountainous area southwest of New River Mesa, and to the south and west by a group of low-lying hills including Black Mountain (Figure 2-1). The groundwater-bearing portion of the subbasin is a small dissected alluvial plain located in the far northern portion of the AMA.

Compared to other subbasins in the AMA, the Carefree Subbasin is relatively shallow (approximately 2,000 feet) and is filled with older, partially consolidated to consolidated sedimentary rocks (Pewe and Dorn, 1989). The primary aquifer in the basin is the Carefree Formation, which consists of alluvial fan and playa deposits (1989). The Carefree Formation consists of five members, of which only the Grapevine member is a significant source of groundwater. The Carefree Formation is underlain by volcanic rocks.

Groundwater in the Carefree Subbasin generally moves west-southwest. The general direction of groundwater flow probably has not changed since groundwater pumping has commenced in the subbasin. Mountain-front recharge occurs along the northeast and eastern portions of the subbasin, and groundwater flow is generally from east to west in that area. Streambed recharge also occurs along the channel of Cave Creek in the northwestern portion of the subbasin. Other ephemeral washes draining upland areas also contribute to groundwater recharge. Groundwater leaves the basin and flows into the East SRV Subbasin.

Detailed water level data prior to development is unavailable for the Carefree Subbasin. However, groundwater pumping in the Carefree Subbasin has had a serious impact on groundwater levels. Water levels began declining in the early 1960s with the onset of pumping. In the center of the basin near the Carefree Airport, a cone of depression has formed as a result of heavy pumping associated with golf courses. Water-level declines in this area have exceeded 10 feet per year (Figure 2-4) (Bernier, 1992). However, since the early 1990s, many of the golf courses in the area have ceased pumping groundwater and have converted to CAP and commingled water because of concerns raised regarding the impacts on the aquifer and the supply for other users.

Water elevations in 1998 range from 2,000 feet above msl in the northwestern area of the subbasin to 2,450 feet above msl in northeastern area of the subbasin. Depth to groundwater in the Carefree Subbasin in 1998 ranged from less than 30 feet below land surface near Cave Creek to over 390 feet below land surface in the eastern part of the basin.

The Carefree Subbasin aquifers are relatively shallow and unproductive. Under the AWS Rules, current and committed demand for groundwater in storage to a depth of 1,000 feet has already been completely accounted for in the northern part of the subbasin.

2.3.9 Land Subsidence

Land subsidence is the lowering of the earth's surface and may occur when groundwater pumping lowers the water level or hydraulic pressure in an aquifer to the extent necessary to cause compression of the alluvial sediments. This results in a drop in elevation and can result in cracks and fissures emerging at land surface. The drop in land surface elevation occurs as the fine-grained sediments in the dewatered zone of the aquifer become compressed as a result of the absence or reduction of the hydraulic pressure on the sediments and the increase in the intragranular stress. The compression of sediments signifies the reduced pore space and a reduction in aquifer storage capacity that can never be regained (Pewe, 1990). Land subsidence can also cause considerable damage to sewage systems, well casings, and building foundations.

If land subsides at the same rate over a large area, there is less impact to surface activities than if adjacent land subsides at different rates. Such "differential subsidence" can occur when subsurface conditions change over a short distance. This can occur near bedrock, around faults, and in areas where the composition of subsurface sediments changes abruptly.

Earth fissures are long, narrow, eroded tension cracks and are associated with land subsidence caused by groundwater withdrawals. They have primarily formed near the margins of mountains or outlying bedrock outcrops where groundwater declines have occurred. Some are very deep, perhaps extending to the water table. Fissures often open up very swiftly after storms and can increase in size due to erosion from surface runoff (Pewe, 1990). As a result, fissures can be conduits for contaminated water to enter the aquifer directly without the normal filtration and purification that occurs when these same waters infiltrate the ground and percolate through thick layers of sediment.

Several areas of subsidence and fissures exist in the Phoenix AMA. In the West SRV Subbasin, subsidence of up to 17 feet and the development of earth fissures has occurred in an area of approximately 140 square miles near Luke Air Force Base. The greatest hazard to the area as a result of the subsidence has been flooding; in 1992, extensive flooding caused approximately $3 million in damages. It became necessary to re-level the Dysart Drain at a cost of approximately $16 million and to re-level fields and repair irrigation ditches in this area (Schumann and O'Day, 1995 and Gelt, 1992). The total cost to repair and improve subsidence-related problems has been in excess of $22 million at Luke Air Force Base. Another structure, a major flood control dam owned by the Maricopa Flood Control District and located within the White Tank Mountains watershed, has been determined a "significant safety hazard" by the Dam Safety Section of the Department. Constructed in 1952, this dam has lost 4.5 feet in elevation due to subsidence. The total project cost for modifying the dam to meet current dam safety standards is estimated at $2.4 million.

In the East SRV Subbasin, land subsidence and the development of earth fissures has also occurred in the Queen Creek, east Mesa, Apache Junction, and Paradise Valley areas (Schumann and Genualdi, 1986). In the Queen Creek area, an area of approximately 230 square miles north of the Santan Mountains had subsided more than 3 feet by 1977. Over 5 feet of land subsidence occurred east of Mesa between 1948 and 1981. In the vicinity of Apache Junction, over 2 to 3 feet of subsidence has been documented since the early 1970s, and earth fissuring represents an ever-present concern. Both the Salt-Gila Aqueduct of the CAP and the Maricopa County-Vineyard Flood Control Dike run directly through the subsidence and earth fissure zone (Raymond, undated). As much as 5 feet of land subsidence occurred in the Paradise Valley area between 1965 and 1982. In 1980, an earth fissure opened in Paradise Valley at a residential construction site. It was the first known occurrence of a fissure in a densely populated area (Pewe, 1990). The fissure cost approximately $500,000 in repair and planning expenses (Larson and Pewe, 1986). At least 0.5 feet of subsidence has been documented in the central Scottsdale area where water levels have declined by 200 to 300 feet since development has occurred (Schumann, 1974). Problems caused by subsidence in these areas resulted in a need to repair sewer lines that had undergone a change in gradient and caused an interruption in flow (Gelt, 1992). All of these areas are characterized by extensive historic groundwater withdrawals and water level declines.

2.3.10 Waterlogged Areas

In the West SRV, the area in the vicinity of the Buckeye Water Conservation and Drainage District, the St. Johns Irrigation District, and the Arlington Canal Company has an extremely shallow depth to groundwater. There are several possible causes for waterlogging in the area, including the natural drainage of the East SRV and West SRV toward the confluence of the Gila and Salt Rivers, crop irrigation and canal seepage, and treated wastewater discharged to the Salt River from the City of Phoenix's 23rd Avenue and 91st Avenue wastewater treatment plants. The combined wastewater discharges continue today at approximately 148,000 acre-feet per year.

In some areas, the current depth to water is less than 10 feet. For certain crops to be grown, the surrounding land must be drained and dewatered. In the aforementioned irrigation districts, systems of drainage channels are operated. These channels divert and discharge groundwater and surface runoff from the area to the Salt and Gila Rivers.

High salinity present in the waterlogged area has worsened over time as the salts delivered in irrigation water have accumulated. Deep percolation of water in an effort to leach salts from the root zone has further pushed salts into the groundwater, although this has been somewhat mitigated by the influx of treated wastewater from the plants in certain parts of the waterlogged area.

2.3.11 Groundwater Quality

Groundwater can be affected by the presence of elevated concentrations of inorganic and organic constituents that make the water unacceptable for potable use due to health concerns or due to negative aesthetic characteristics. The elevated concentrations of these constituents are both from historical practices and natural sources. In some cases, this water may be acceptable for non-potable uses in place of potable groundwater. Water quality conditions are briefly discussed below and in greater depth in Chapter 7.

In the AMA, large volumes of groundwater are unsuitable for use due to elevated concentrations of hazardous substances such as volatile organic compounds, petroleum hydrocarbons, and pesticides. Groundwater contaminated above Maximum Contaminant Levels cannot be delivered for drinking water use. Many municipal wells, particularly in the central Phoenix and west Phoenix areas, have been closed due to contamination from past disposal practices, leaking underground storage tanks, and the presence of pesticides. Naturally occurring substances such as radon and arsenic have also caused the closure of municipal supply wells.

Non-point source contamination, or contamination that has not originated from one single source, has also rendered large volumes of groundwater unsuitable for most uses. Contaminants such as nitrate, sulfate, and dissolved solids are present in elevated concentrations due to wastewater discharge, septic tanks, agriculture, urban stormwater, and other causes. Although many non-point source contaminants such as sulfate and total dissolved solids are not regulated for drinking water use, their presence in groundwater at elevated concentrations can cause aesthetic problems in drinking water and can render groundwater unsuitable for other uses, such as agricultural irrigation.

2.4 SURFACE WATER

The Phoenix AMA is drained by the Gila River and four principal tributaries: the Salt, Verde, Agua Fria, and Hassayampa Rivers. Other tributaries include Queen Creek, New River, Skunk Creek, Cave Creek, Waterman Wash, and Centennial Wash. In the last 100 years, significant infrastructure has been built on major rivers in the AMA to capture and store as much surface water as possible for users in the AMA and elsewhere. Despite the regulatory control afforded by the dam and reservoir system, annual diversions of surface water for downstream users varies greatly with the amount of water that flows into the reservoirs from the watershed. The amount of water stored for use is especially dependent on the snowpack and resultant snowmelt of each winter storm season on the watershed. This can be highly variable from year to year, with extensive droughts not uncommon in recent history. When surface water supplies are insufficient to meet demand, supplies are often supplemented by groundwater pumping to make up the shortfall. In years of excessive snowmelt, water may need to be spilled from storage reservoirs. Although some spillwater can augment supplies in the AMA, much of it flows through the AMA without being used. Environmental concerns, cost, and a shortage of suitable sites make it highly unlikely that any additional large-scale regulatory projects will be created to further develop surface water storage capacity in the AMA.

Other than Colorado River water delivered to the AMA through the CAP aqueduct (discussed separately in section 2.5), the Salt and Verde Rivers are the principal sources of surface water in the AMA. Most of the surface water from the Salt and Verde Rivers is appropriated to downstream users in irrigation districts and is limited for use to lands within the Salt River Project, the Roosevelt Water Conservation District, and the Buckeye Water Conservation and Drainage District. The Gila and Agua Fria Rivers also provide surface water. Water from the Gila River is used mainly for agricultural uses in the San Carlos Irrigation District on the Gila River Indian Community (partially within the AMA) and in the Buckeye Water Conservation and Drainage District. Water from the Agua Fria River is used by Maricopa Water District in the West SRV Subbasin. Small, localized surface water appropriations have been made to users from Cave Creek, Queen Creek, and Centennial Wash. Many municipal, industrial, and agricultural users are outside of the aforementioned district boundaries and are ineligible to receive surface water supplies.

Surface water flow recharges the Phoenix AMA aquifer by infiltrating through stream channel sediments into the aquifer. Stream channel recharge is a component of net natural recharge and is incorporated into water budget estimates of Phoenix AMA water supply (see Chapter 11).

2.4.1 Salt and Verde Rivers

The Salt River originates in eastern Arizona and drains approximately 6,000 square miles of the Mogollon Rim area in the east-central part of the state. The Salt River channel enters the AMA north of the Goldfield Mountains; crosses toward the southwest through the East SRV and West SRV Subbasins and the cities of Mesa, Tempe, and Phoenix; and finally joins the Gila River near Laveen. Downstream from the Granite Reef Diversion Dam, the Salt River is ephemeral, flowing in response to flooding or reservoir releases. The Salt River is perennial further downstream due to effluent discharges from the 23rd Avenue and 91st Avenue wastewater treatment plants.

The Verde River originates in the Chino Valley north of Prescott. It is a perennial river that drains approximately 7,000 square miles of central Arizona. The Verde River channel enters the AMA in the north Fountain Hills Subbasin and moves southward where it joins the Salt River between Stewart Mountain Dam and Granite Reef Diversion Dam. The Verde River is regulated by Horseshoe Dam outside the AMA and Bartlett Dam within the AMA, both of which are part of the Salt River Project.

The Salt River flowed perennially before the late 1800s (Lee, 1905). The diversion dams, canals, and laterals constructed in the late 1880's along the Salt River were inadequate to regulate the effects of drought and flood and to produce a reliable and safe water supply for agricultural irrigation uses in the Salt River Valley. In response, the Salt River Valley Water Users Association was formed in 1903 for the purpose of furnishing water, power, and drainage for participating landowners in the Valley. A series of four regulatory storage reservoirs and five dams were constructed on the Salt River to accomplish this goal. On the Verde River, the United States Bureau of Reclamation (USBR) constructed Bartlett Dam in the 1930's and the Phelps-Dodge Corporation constructed Horseshoe Dam in the 1940s. Collectively, these projects make up the Salt River Project. Table 2-1 shows the dams and reservoir capacity of the Salt River Project. Total water storage capacity of the Salt River Project is nearly 3.6 million acre-feet, although a large portion of this space is usually left vacant for flood storage. At Granite Reef Diversion Dam, which is southwest of the confluence of the Salt and Verde Rivers and within the AMA, water is diverted to users through the Arizona Canal and the South Canal.

TABLE 2-1
SALT AND VERDE RIVERS - WATER STORAGE AND DIVERSION PROJECTS
PHOENIX ACTIVE MANAGEMENT AREA

River	Dam	Reservoir	Storage Capacity (acre-feet)
Salt	Roosevelt	Roosevelt	2,910,200
	Horse Mesa	Apache	245,100
	Mormon Flat	Canyon	57,900
	Stewart Mountain	Saguaro	69,800
	Granite Reef	(N/A - diversion dam)	N/A
Verde	Bartlett	Bartlett	178,200
	Horseshoe	Horseshoe	152,900

Because of concern over detrimental environmental impacts, two additional dams to increase storage capacity on the Salt and Verde Rivers (Orme Dam on the Salt River and Cliff Dam on the Verde River) were never built. An alternative to the construction of Orme Dam (known as Plan 6) raised Roosevelt Dam 76 feet in 1996 and made important flood-handling modifications to Stewart Mountain Dam. The effect of raising Roosevelt Dam was an increased capacity of approximately 1.5 million acre-feet, of which 255,100 acre-feet will be used for regulatory storage and the remainder left vacant to provide flood storage. From 1913 to 1997, diversions have ranged from 506,000 to 1,360,000 acre-feet per year. The median diversion has been approximately 808,000 acre-feet. Most Salt and Verde River water is appropriated to shareholders of the Salt River Valley Water Users Association (Salt River Project) for use on lands within the Project. The Salt River Project encompasses portions of the East SRV and West SRV Subbasins in the AMA, including portions of Glendale, Peoria, Phoenix, Scottsdale, Tempe, Chandler, Gilbert, and Mesa. (See Figure 4-2 in Chapter 4.) Although Salt River Project still provides water for significant agricultural use, much of the lands within the project boundaries are highly urbanized, including mature development in central Phoenix, south Scottsdale, Tempe, and Mesa. Most new urban development of the Phoenix urban area is occurring outside the Project's boundaries and is not eligible to directly receive water from the Project. Salt River Project water may be delivered outside of the Project's boundaries only if it is exchanged for another source.

Some Salt and Verde River system water has also been adjudicated to or agreed to be delivered to several other irrigation districts, including the Buckeye Water Conservation and Drainage District, Roosevelt Water Conservation District, St. Johns Irrigation District, and Peninsula Ditch Water Company. Salt and Verde River water partially meets water demand within these district boundaries but must be supplemented with other sources, including groundwater. Water rights settlements have allocated Salt and Verde waters to the Fort McDowell Indian Community and Salt River Pima-Maricopa Indian Community, which will be used to meet urban and agricultural demand within these communities. In 1946, the City of Phoenix increased the capacity of Horseshoe Dam by constructing spillway gates; as compensation, it is eligible to receive a portion of Verde River water. Water stored behind additional storage capacity on Roosevelt Dam created by Plan 6 is divided by Salt River Project and the cities of Phoenix, Mesa, Chandler, Scottsdale, Tempe, and Glendale. Plan 6 water is not restricted for use within Salt River boundaries.

2.4.2 Gila River

The Gila River channel enters the AMA between the San Tan and Sacaton Mountains near Sacaton. It crosses northwest and west near the Sierra Estrella Mountains and the Buckeye Hills, and exits the AMA at Gillespie Dam. Prior to 1890, the river flowed perennially through the AMA (Lee, 1904). The river is currently regulated by the Ashurst-Hayden Dam east of Florence outside the AMA. Most natural surface water flows are diverted to the San Carlos Irrigation District at the Ashurst-Hayden Dam. The district encompasses a portion of the Gila River Indian Community in the AMA and the community uses the water for agricultural purposes. The river flows downstream from the dam when floods exceed the dam's diversion capacity and is perennial for a couple miles above the confluence with the Salt River. Below the confluence with the Salt River, the Gila River is perennial due to effluent discharge in the Salt River from the City of Phoenix's 23rd Avenue and 91st Avenue wastewater treatment plants. Much of this water is diverted for agricultural irrigation by the Buckeye Water Conservation and Drainage District and the Arlington Canal Company.

2.4.3 Agua Fria River

The Agua Fria River is an intermittent to ephemeral stream that begins northeast of Prescott and drains part of central Arizona between Prescott and Phoenix. The Agua Fria River enters the AMA approximately 20 miles north of Peoria, flows south along the western edge of the Phoenix metropolitan area and joins the Gila River south of Avondale. The drainage area of the Agua Fria River and its tributaries is approximately 2,000 square miles.

The Agua Fria River is regulated at the northern boundary of the AMA by New Waddell Dam, which forms Lake Pleasant. At Lake Pleasant, which functions as regulatory storage for both the Agua Fria River and Colorado River water brought into the AMA by the CAP, water is diverted by the Maricopa Water District to the Beardsley Canal, a 30-mile long canal that cuts southward across the West SRV Subbasin east of the White Tank Mountains. Maricopa Water District delivers a combination of Agua Fria River water, groundwater, and CAP water to users in the district. Downstream from the dam, the Agua Fria River is ephemeral.

2.4.4 Other Tributaries

Other tributaries exist in the AMA that are not significant sources of surface water supply, including the Hassayampa River, Cave Creek, Queen Creek, New River, Skunk Creek, Waterman Wash, and Centennial Wash. All of these tributaries are ephemeral with the exception of the Hassayampa River, which is intermittent to ephemeral.

2.5 CENTRAL ARIZONA PROJECT

The CAP was constructed to annually deliver 1.5 million acre-feet of Arizona's allocation of Colorado River water to central and southern Arizona through a series of aqueducts and pumping stations. The project is over 300 miles long and lifts Colorado River water 2,400 feet to its final destination in Tucson. A significant portion of CAP water is stored in Lake Pleasant behind New Waddell Dam at the northern edge of the AMA. The dam was constructed as a part of the Plan 6 alternative to the construction of Orme Dam and Cliff Dam on the Salt River and Verde River, respectively. Turnouts from the CAP aqueduct connect it to municipal water treatment plants and irrigation district canals for distribution.

CAP water is not freely available to all municipal, industrial, and agricultural users in the AMA. CAP water was originally allocated in 1983 to parties among Indian users, non-Indian municipal and industrial (M&I) users, and agricultural users who requested an allocation. Allocations for Indian and M&I users are fixed; allocations for agricultural users are calculated as a percentage of remaining CAP water. Contracts for the allocations are made with the Central Arizona Water Conservation District (CAWCD), which is also responsible for operating and maintaining CAP infrastructure and managing the repayment of the costs to build CAP to the federal government. As of 1995, a total of 375,845 acre-feet of CAP water have been allocated to M&I and agricultural users in the Phoenix AMA.

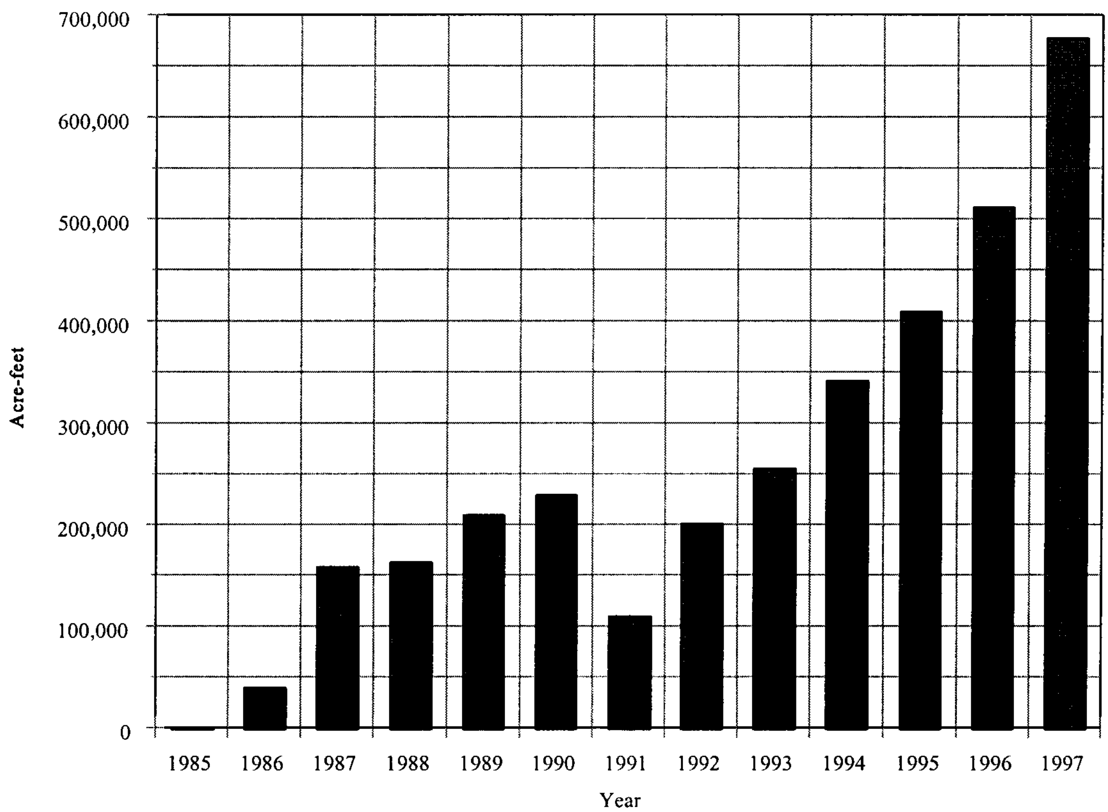
CAP water was first delivered and used in the AMA in 1985 and its use has grown steadily since (see Figure 2-7). However, the relatively high cost of the water compared to pumping groundwater has caused several irrigation districts to turn back their original allocations. Unused agricultural water has been "pooled" and offered by CAWCD to irrigation districts at a substantial discount to entice use and generate revenue to pay for the capital costs of the canal. Many M&I users (both inside and outside the AMA) are distant from the CAP canal; lack of physical infrastructure needed to convey CAP water has hindered its use. CAWCD has offered short-term contracts for unused allocated M&I water (known as "excess" CAP water) to users in the AMA. In the future, M&I allocations may change as allocated entities buy or sell unused allocations. CAP water may also be used to settle Indian water rights claims in the future.

A total of over 677,000 acre-feet of CAP water, including both CAP water delivered to allocated entities and excess CAP water, was used for non-Indian purposes in the AMA in 1997. This total includes both direct use of the water and direct and indirect recharge of CAP water. Direct recharge can occur in basins, streambeds, or injection wells. A total of nearly 56,000 acre-feet of CAP water was directly recharged in this manner in 1995. Indirect recharge, known as water stored at "groundwater savings facilities," allows existing groundwater to remain underground by replacing groundwater pumping with CAP use, typically by irrigation districts for agricultural users. A total of approximately 56,500 acre-feet of CAP water was delivered to irrigation districts as groundwater savings facilities in 1995. Recharge projects are administered statewide by the Department under the 1994 Underground Water Storage, Savings, and Replenishment Program (see Chapter 8). Direct and indirect recharge projects that have received permits in the Phoenix AMA are discussed and tabulated in Appendix 8A.

2.6 EFFLUENT

Effluent production is tied to population size. Based on the assumption that effluent is produced at wastewater treatment plants at a rate of 100 gallons per person per day, an estimated 286,000 acre-feet of effluent were produced within the Phoenix AMA in 1995. For much of Glendale, Mesa, Phoenix, Scottsdale, Sun City, and Tempe, wastewater is piped and treated at the 91st Avenue WWTP. This facility accounts for most of the effluent produced in the AMA, averaging approximately 159,000 acre-feet of effluent per year since 1989. From this facility, up to 60,000 acre-feet per year of effluent have been piped from the plant to the Palo Verde Nuclear Generating Station, which has a contract to receive the effluent through the year 2027; a total of 48,899 acre-feet were delivered to the plant in 1995. Another 30,000

FIGURE 2-7
CENTRAL ARIZONA PROJECT WATER USE: 1985-1997
PHOENIX ACTIVE MANAGEMENT AREA



acre-feet are contracted to the Buckeye Water Conservation and Drainage District through the year 2030 to irrigate crops. The remaining effluent from this plant, approximately 53,000 acre-feet per year, flows out of the AMA in the Salt and Gila River channels. Much of the effluent from Phoenix's 23rd Avenue WWTP is used to irrigate crops in the Roosevelt Irrigation District. Significant quantities of effluent from Chandler's Lone Butte WWTP is used to irrigate crops within the Gila River Indian Community. Much of the remaining direct use from other wastewater treatment plants across the AMA consists primarily of landscape watering by industrial users and municipally served facilities. The City of Scottsdale is currently developing an extensive reclaimed water distribution system to deliver effluent to a number of north Scottsdale golf courses.

Small quantities of effluent were used for artificial recharge in 1995. A total of approximately 6,500 acre-feet of effluent were directly recharged in basins, streambeds, or injection wells in 1995. Approximately 460 acre-feet of effluent were delivered to irrigation districts acting as groundwater savings facilities in 1995. Recharge projects are administered statewide by the Department under the 1994 Underground Water Storage, Savings, and Replenishment Program. Direct and indirect recharge projects that have received permits in the Phoenix AMA are discussed and tabulated in Appendix 8A.

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